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memorandum

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SUBJECT: Vacuum Loads on the AAA $\beta = 0.175$ Spoke Cavity

This note describes the results of finite element structural analysis of the AAA $\beta = 0.175$ spoke cavity under vacuum loading. The results indicate that the cavity should not be put under vacuum load without the stiffener ring constrained.

DO NOT PUT THE AAA β = 0.175 SPOKE CAVITY UNDER VACUUM LOAD WITHOUT THE STIFFENER RING CONSTRAINED.

The AAA β = 0.175 2-gap 350 MHz spoke resonator cavity must be put under vacuum at many stages of the manufacturing process and during the testing process. Some of this will take place with the cavity at ambient temperature where the yield stress is approximately 7000 #/in^2. Account must also be take of the effect of the reduction of wall thickness due to BCP. For the sake of conservatism, a total material removal by BCP of 400 μ-meters was assumed. This reduces the cavity wall thickness from 3.5 to 3.1 millimeters.

A description of the initial structural analysis is given in Reference 1. This analysis utilized a complex three-dimensional model of the full cavity. It did not include the details of the weld joints or consider the effect of reduced wall thickness due to BCP. The cavity beamtube and stiffener were constrained per Case 4. As a consequence, somewhat lower stresses were predicted.

The region of concern during vacuum leak testing is the cavity endwall. The geometry of the endwalls of the AAA β = 0.175 2-gap 350 MHz spoke resonator cavity is described on LANL drawing #143Y607200-D2 shown on Figure 1. The material properties used were modulus = 1.42 10^7 #/in^2 and Poisson's Ratio = 0.38. An axi-symmetric COSMOS/M model was used. The model incorporates a 2-millimeter thick weld joint. Four cases were analyzed with a vacuum load of one atmosphere. The four analysis cases were:

1. Beamtube and stiffener unconstrained.
2. Beamtube constrained.
3. Stiffener constrained.
4. Beamtube and stiffener constrained.

The results are listed on Table I and are plotted on Figures 2 through 5.With no axial constraints and with only the beamtube constrained, there are Von-Mises stresses in excess of yield over more than 10% of the endwall. For Case 1, most of the stresses in excess of yield are in the region between the stiffener and the outer diameter. For Case 2, the highest stresses are in the region where the beamtube intersects the dish. For Cases 3 and 4, the stresses are mostly below 2,000 #/in^2.

TABLE I: STRESSES DUE TO VACUUM LOADS

LOAD CASE	BEAMTUBE CONST.	STIFFENER CONST.	MAX AXIAL DISPLACE. inch	MAX Von-Mises Stress #/in^2	% of Nodes with Von-Mises Stress >3500 #/in^2	% of Nodes with Von-Mises Stress >7000 #/in^2
1	NONE	NONE	0.0299	19,824	31.07	11.73%
2	FIXED	NONE	0.0146	23,881	31.55	12.90%
3	NONE	FIXED	0.0029	6,158	0.43	0.00%
4	FIXED	FIXED	0.0013	5,471	0.24	0.00%

The conclusion is that loading cases 1 and 2 must be avoided at ambient temperature. The recommendation is that the cavity be constrained per load case 3 any time that the cavity is under vacuum.

References:

1. R. P. LaFave, “Structural and RF Analysis of LANL 2 Gap, 350 MHz Spoke Resonator Cavity,” LA-UR-01-1454

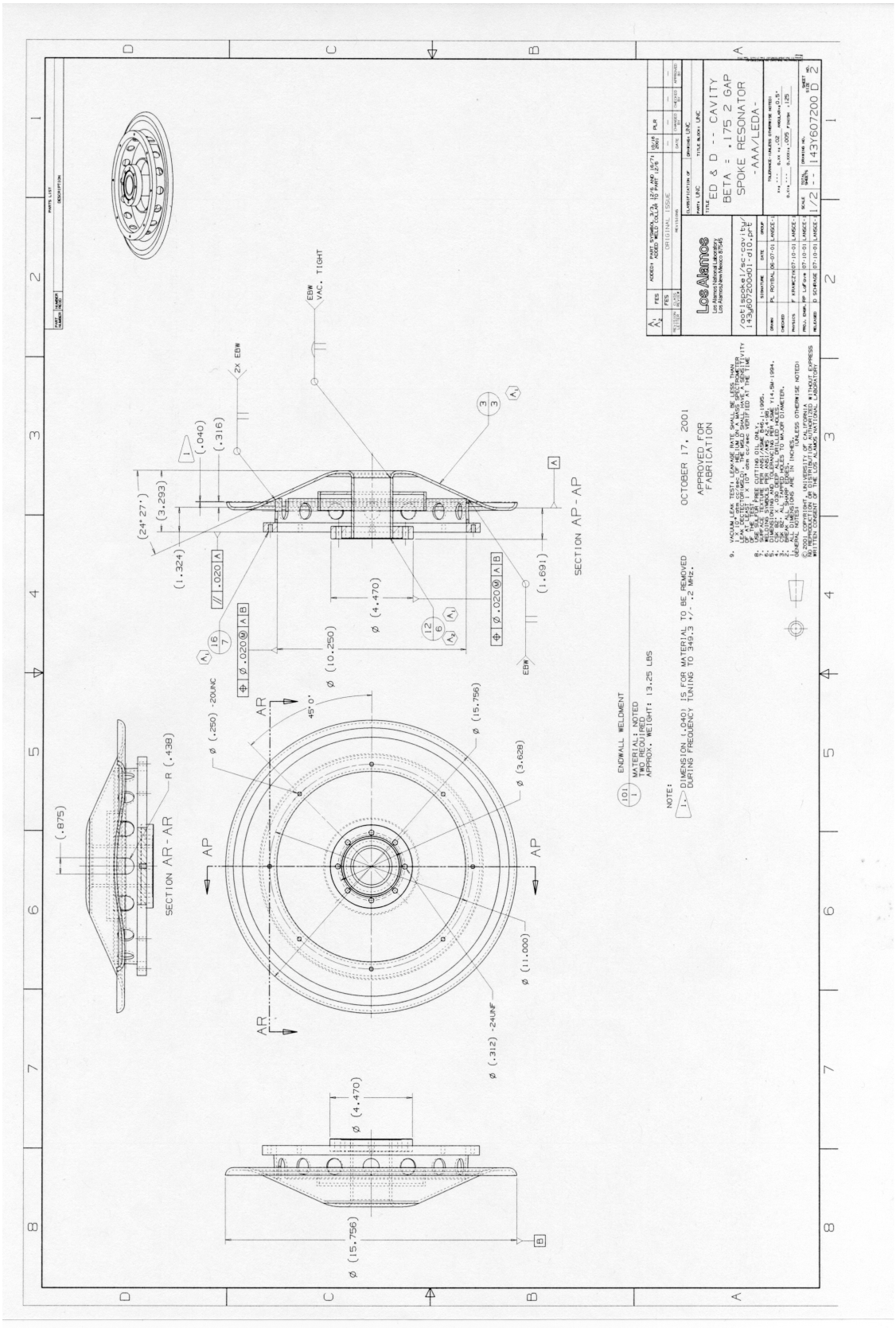

FIGURE 1:SPOKE CAVITY ENDWALL

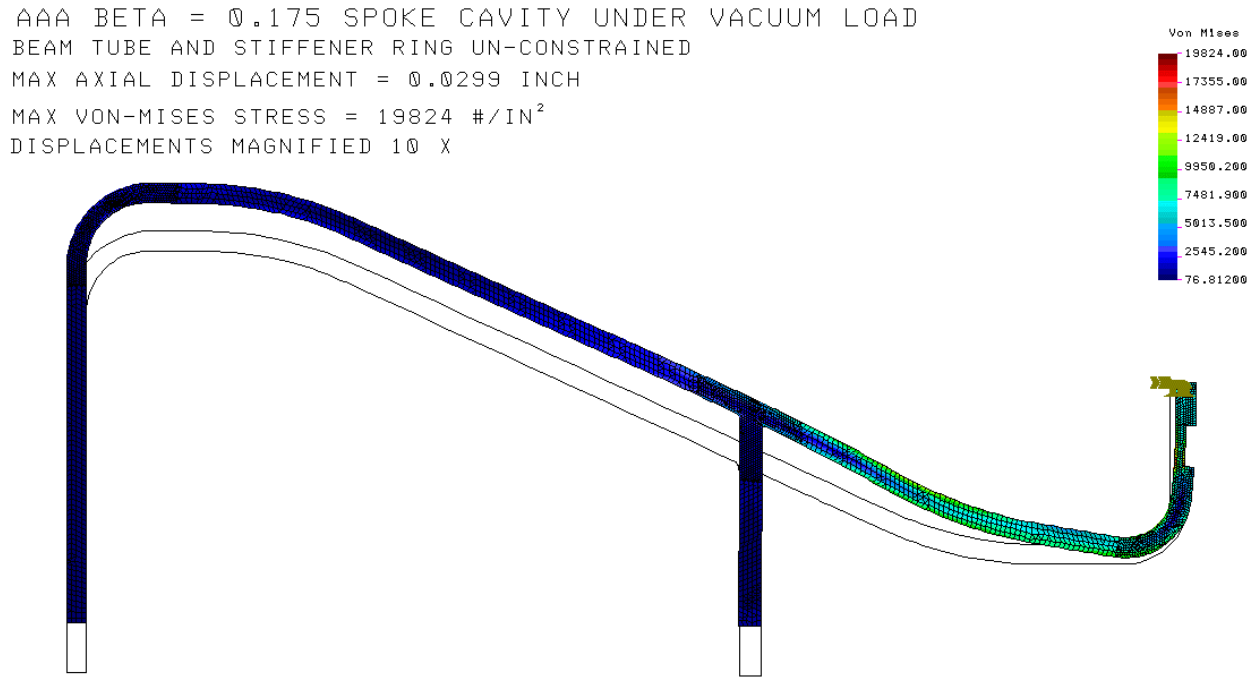

FIGURE 2. LOAD CASE #1 – UNCONSTRAINED CAVITY

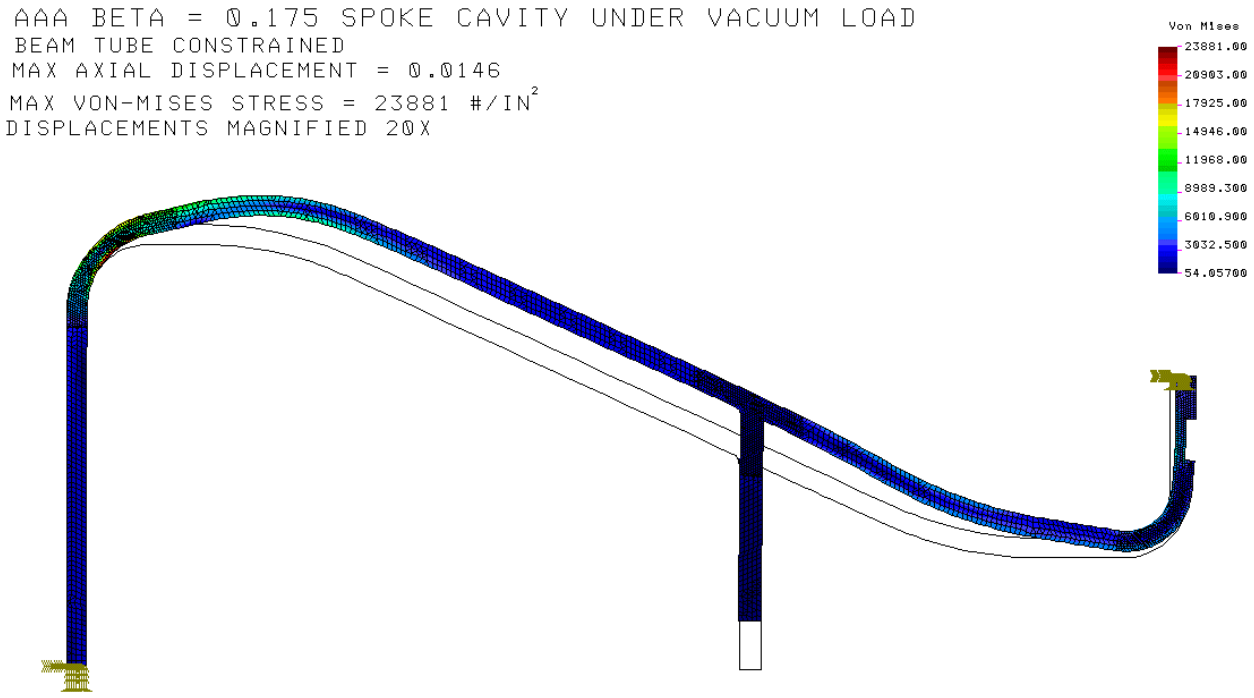

FIGURE 3. LOAD CASE #2 – BEAM TUBE CONSTRAINED

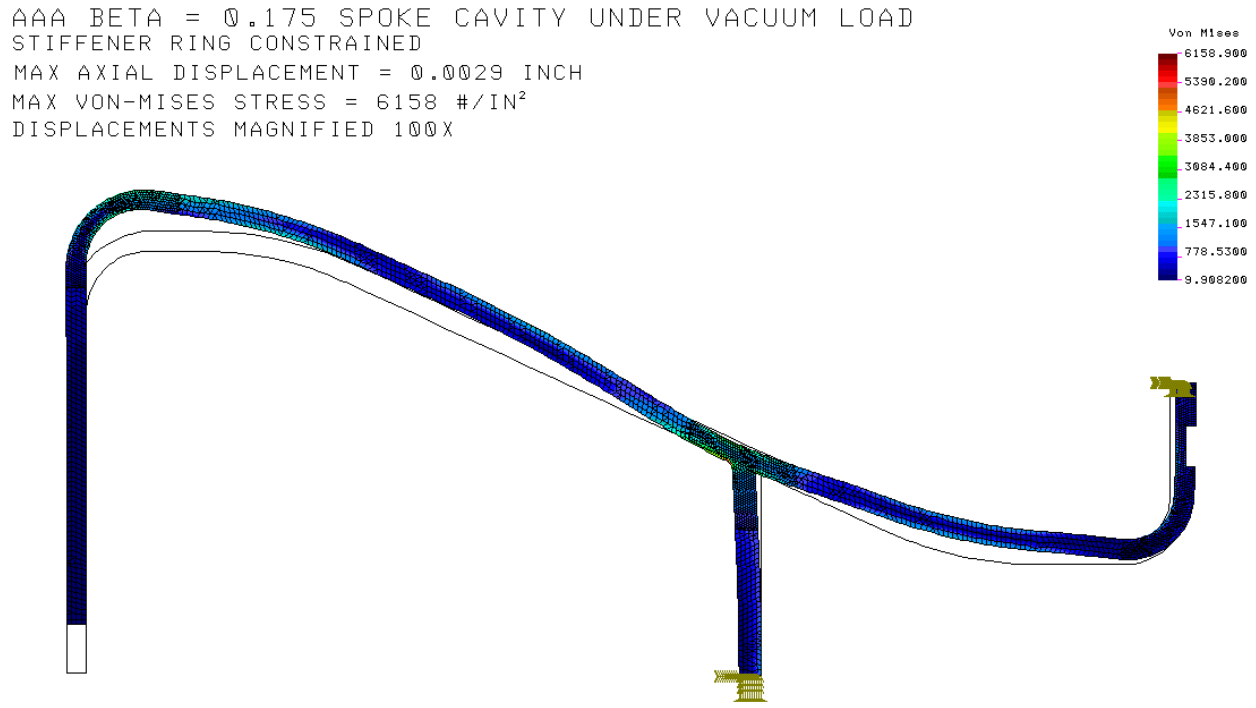

FIGURE 4. LOAD CASE #3 – STIFFENER RING CONSTRAINED

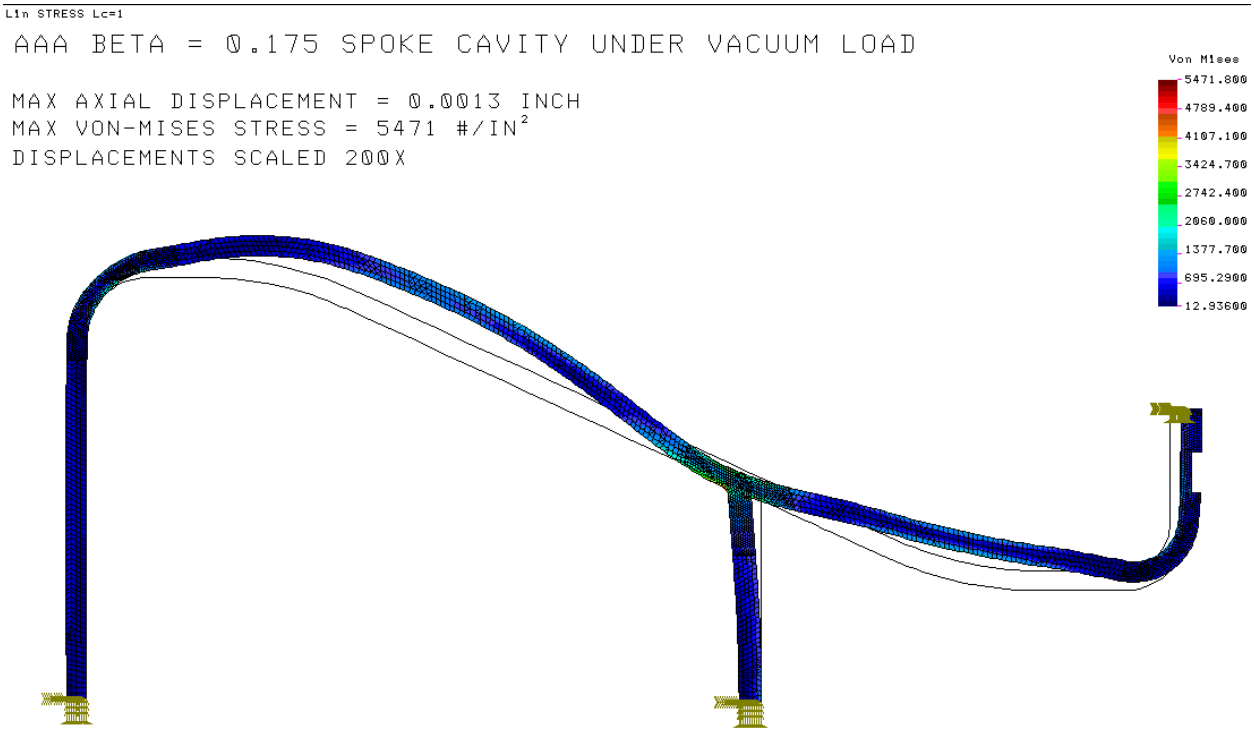

FIGURE 5. LOAD CASE #4 – BEAM TUBE & STIFFENER RING CONSTRAINED

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